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(54) **BASE STATION APPARATUS, TERMINAL APPARATUS, AND METHOD**

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(Continued)

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CPC ***H04W 4/06*** (2013.01); ***H04L 5/0051*** (2013.01); ***H04W 24/02*** (2013.01); ***H04W 72/005*** (2013.01); *H04L 12/189* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2014/0126403 A1* 5/2014 Siomina H04J 11/005 370/252
2014/0233457 A1* 8/2014 Koutsimanis H04J 11/005 370/328

(Continued)

OTHER PUBLICATIONS

Ericsson, "RAN 4 scope for NAICS work", 3GPP TSG-RAN WG4 Meeting #71; R4-142734, Seoul, Korea, May 19-23, 2014, 7 pages.

(Continued)

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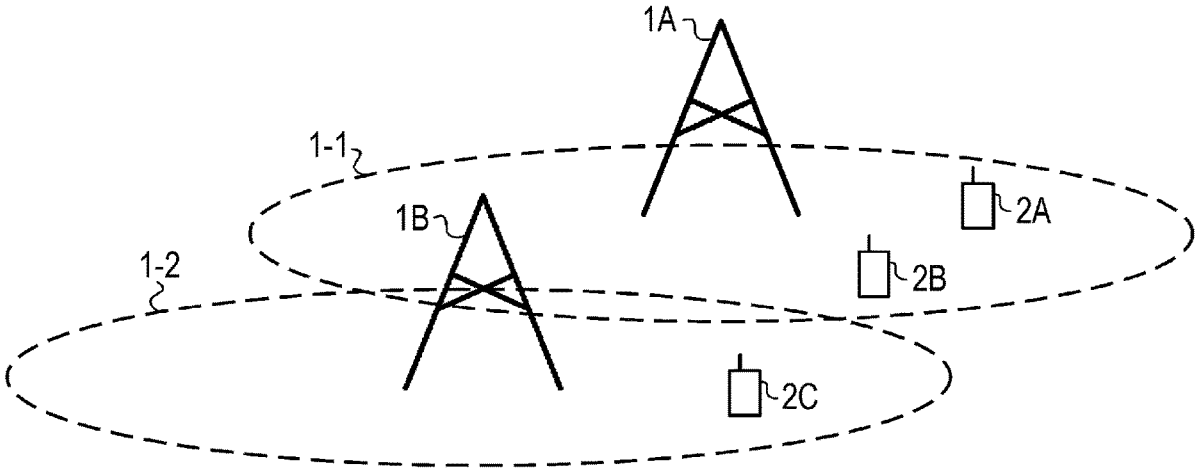
(57) **ABSTRACT**

A terminal apparatus is a terminal apparatus that communicates with a base station apparatus and includes a reception unit that receives NAICS assistance information from the base station apparatus. The NAICS assistance information includes assistance information used by the terminal apparatus in order to cancel or suppress interference of an neighbor cell and includes information related to power of a downlink shared channel used by the base station apparatus. The assistance information includes information related to a physical cell ID, information related to the number of antenna ports for a cell-specific reference signal, information related to an MBSFN subframe, a transmission mode, information related to a power ratio of the downlink shared channel between OFDM symbols, and information related to a power ratio of the cell-specific reference signal and the downlink shared channel.

6 Claims, 3 Drawing Sheets



(51) **Int. Cl.**

H04W 24/02	(2009.01)
H04L 5/00	(2006.01)
H04W 72/00	(2009.01)
H04L 12/18	(2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0195820	A1*	7/2015	Jung	H04W 72/042 370/329
2015/0326290	A1*	11/2015	Harrison	H04B 7/0456 375/260
2015/0365178	A1*	12/2015	Maattanen	H04B 17/345 370/329
2015/0373569	A1*	12/2015	Hwang	H04W 72/082 370/235
2016/0021565	A1*	1/2016	Kim	H04J 11/004 370/329
2017/0005744	A1*	1/2017	Li	H04W 72/082

OTHER PUBLICATIONS

Nvidia, "Remaining aspects of higher-layer signaling for NAICS", 3GPP TSG-RAN WG1 #77; R1-142588, Seoul, Korea, May 19-23, 2014, 10 pages.

Renesas Mobile Europe Ltd, "On CRS interference mitigation in homogeneous deployments", 3GPP TSG-RAN WG4 Meeting #66bis, R4-131855, Chicago, USA, Apr. 15-19, 2013, 8 pages.

Media Tek, "Status Report to TSG", 3GPP TSG RAN meeting#64, RP-140697, Sophia Antipolis, France, Jun. 10-13, 2014, 12 pages.

Media Tek, Renesas Mobile Europe, Broadcom Corporation, "Study on Network-Assisted Interference Cancellation and Suppression for LTE", 3GPP TSG RAN Meeting #59 , RP-130404, Vienna, Austria, Feb. 26-Mar. 1, 2013, 7 pages.

MediaTek, "Meeting minutes for NAICS ad hoc", 3GPP TSG RAN WG4 Meeting #71, R4-143848, Seoul, Korea, May 19-23, 2014.

Qualcomm Incorporated, "Stage 2 for the FeICIC", 3GPP TSG-RAN WG2 Meeting #80, R2-125759, New Orleans, the USA, Nov. 12-16, 2012.

* cited by examiner

FIG. 1

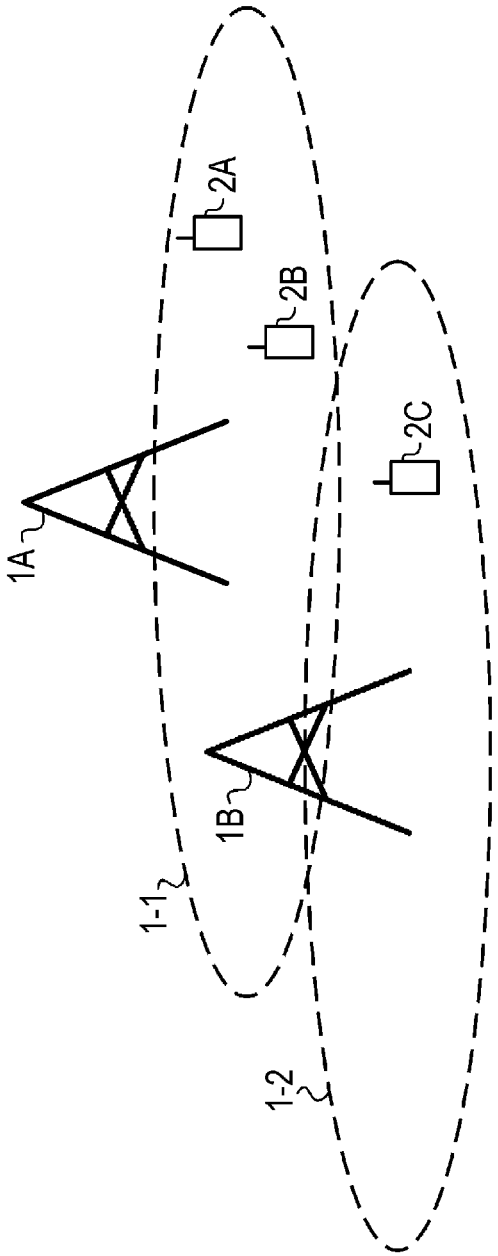
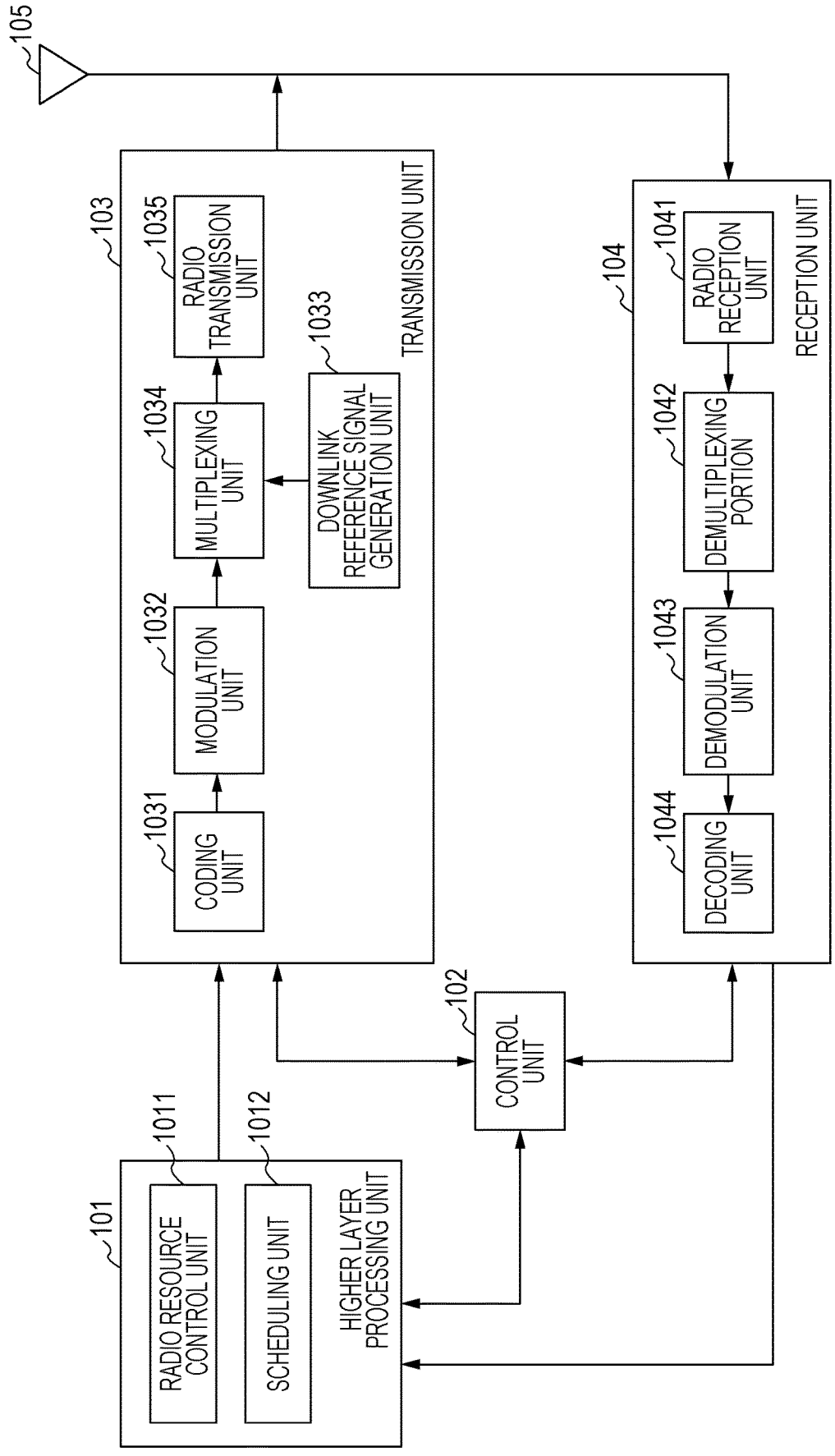


FIG. 2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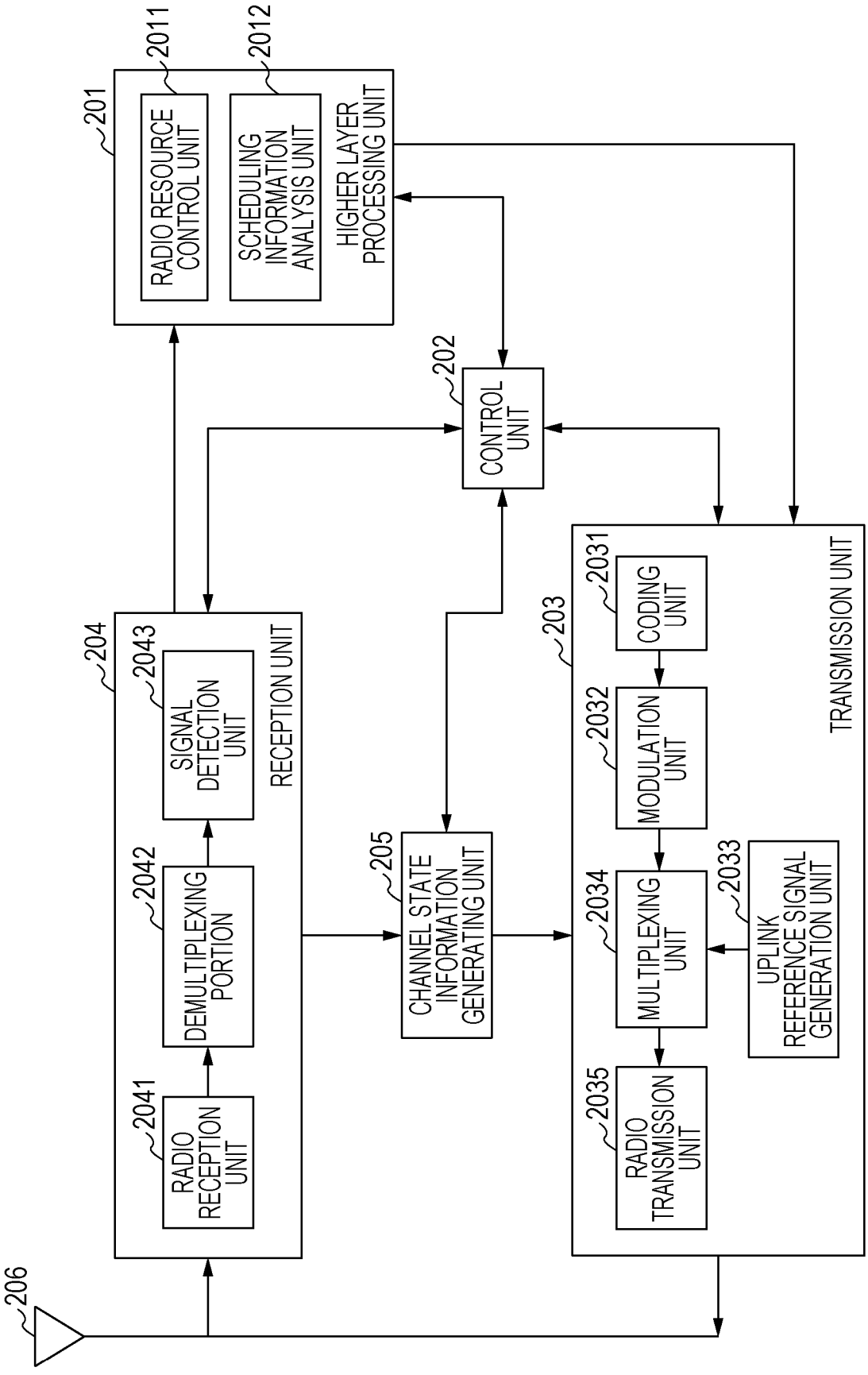
MULTIPLEXING UNIT
1032
MODULATION UNIT
1031
CODING UNIT
104
RECEPTION UNIT
1041
RADIO RECEPTION UNIT
1042
DEMULTIPLEXING PORTION
1043
DEMODULATION UNIT
1044
DECODING UNIT
102
CONTROL UNIT
101
HIGHER LAYER PROCESSING UNIT
1011
RADIO RESOURCE CONTROL UNIT
1012
SCHEDULING UNIT

FIG. 3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RADIO TRANSMISSION UNIT
TRANSMISSION UNIT
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BASE STATION APPARATUS, TERMINAL APPARATUS, AND METHOD

TECHNICAL FIELD

The present invention relates to a base station apparatus, a terminal apparatus, and a method.

BACKGROUND ART

In a communication system such as long term evolution (LTE) and LTE-advanced (LTE-A) by Third Generation Partnership Project (3GPP) or worldwide interoperability for microwave access (WiMAX), a communication area can be enlarged by using a cellular composition in which a plurality of areas covered by a base station apparatus (a base station, a transmission station, a transmission point, a downlink transmission apparatus, an uplink reception apparatus, a transmit antenna group, a transmit antenna port group, a component carrier, or an eNodeB) or a transmission station corresponding to a base station apparatus is arranged in cells. In the cellular composition, frequency efficiency can be improved by using the same frequency between neighbor cells or sectors.

However, in such a cellular composition, a terminal apparatus (a mobile station apparatus, a reception station, a reception point, an uplink transmission apparatus, a downlink reception apparatus, a mobile terminal, a receive antenna group, a receive antenna port group, or user equipment (UE)) in a cell edge region or a sector edge region receives interference from a transmit signal of a base station apparatus constituting another cell or another sector (inter-cell interference or inter-sector interference), thereby posing a problem in that frequency efficiency is decreased.

As a measure against inter-cell interference or inter-sector interference, the speed of reception performance of the terminal apparatus is increased (advanced receiver). For example, in NPL 1, a minimum mean square error interference rejection combining (MMSE-IRC) receiver, an interference cancellation receiver, an interference suppression receiver, a maximal likelihood detection receiver (MLD receiver), and the like are described as a high speed receiver. Accordingly, limitations from inter-cell interference can be alleviated, and thus improvement in frequency efficiency can be achieved.

In the communication system, spatial multiplexing transmission (multi input multi output (MIMO)) is applied in order to realize efficient data transmission. The high speed receiver is used in order to suppress inter-stream interference (inter-layer interference or inter-antenna interference) generated in spatial multiplexing transmission, and thus improvement in frequency efficiency can be achieved.

CITATION LIST

Non Patent Literature

NPL 1: "Study on Network Assisted Interference Cancellation and Suppression for LTE", 3GPP TSG RAN Meeting #59, RP-130404, March 2013.

SUMMARY OF INVENTION

Technical Problem

The high speed receiver requires knowledge or information related to an interference signal (for example, a parameter for demodulation) in order to mitigate interference. However, the base station apparatus transmitting knowledge or information related to an interference signal to the terminal apparatus poses a problem in that signaling overhead is increased. In addition, if the base station apparatus has less knowledge or information related to an interference signal with respect to the terminal apparatus, the terminal apparatus side is required to estimate information as to an interference signal, thereby posing a problem in that the amount of calculation of the terminal apparatus is increased.

The present invention is conceived in view of such matters, and an object thereof is to provide a base station apparatus, a terminal apparatus, and a method that can mitigate interference by using effective knowledge or information as to an interference signal.

Solution to Problem

Composition of a base station apparatus, a terminal apparatus, and a method according to the present invention for resolving the above problems is as follows.

A base station apparatus of the present invention is a base station apparatus that communicates with a terminal apparatus, the apparatus including a transmission unit that transmits NAICS assistance information to the terminal apparatus, in which the NAICS assistance information includes assistance information used by the terminal apparatus in order to cancel or suppress interference of an neighbor cell and includes information related to power of a downlink shared channel used by the base station apparatus, and the assistance information includes information related to physical cell ID, information related to the number of antenna ports for a cell-specific reference signal, information related to an MBSFN subframe, a transmission mode, information related to a power ratio of the downlink shared channel between OFDM symbols, and information related to a power ratio of the cell-specific reference signal and the downlink shared channel.

A method for a base station apparatus of the present invention is a method for a base station apparatus that communicates with a terminal apparatus, the method including a step of transmitting NAICS assistance information to the terminal apparatus, in which the NAICS assistance information includes assistance information used by the terminal apparatus in order to cancel or suppress interference of an neighbor cell and includes information related to power of a downlink shared channel used by the base station apparatus, and the assistance information includes information related to physical cell ID, information related to the number of antenna ports for a cell-specific reference signal, information related to an MBSFN subframe, a transmission mode, information related to a power ratio of the downlink shared channel between OFDM symbols, and information related to a power ratio of the cell-specific reference signal and the downlink shared channel.

A terminal apparatus of the present invention is a terminal apparatus that communicates with a base station apparatus, the apparatus including a reception unit that receives NAICS assistance information from the base station apparatus, in which the NAICS assistance information includes assistance information used by the terminal apparatus in order to cancel or suppress interference of an neighbor cell and includes information related to power of a downlink shared channel used by the base station apparatus, and the assistance information includes information related to physical cell ID, information related to the number of antenna ports for a cell-specific reference signal, information related to an

MBSFN subframe, a transmission mode, information related to a power ratio of the downlink shared channel between OFDM symbols, and information related to a power ratio of the cell-specific reference signal and the downlink shared channel.

A method for a terminal apparatus of the present invention is a method for a terminal apparatus that communicates with a base station apparatus, the method including a step of receiving NAICS assistance information from the base station apparatus, in which the NAICS assistance information includes assistance information used by the terminal apparatus in order to cancel or suppress interference of an neighbor cell and includes information related to power of a downlink shared channel used by the base station apparatus, and the assistance information includes information related to physical cell ID, information related to the number of antenna ports for a cell-specific reference signal, information related to an MBSFN subframe, a transmission mode, information related to a power ratio of the downlink shared channel between OFDM symbols, and information related to a power ratio of the cell-specific reference signal and the downlink shared channel.

Advantageous Effects of Invention

According to the present invention, interference can be effectively mitigated in a radio environment where an interference signal arrives.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram illustrating an example of a communication system according to the present embodiment.

FIG. **2** is a block diagram illustrating a composition example of a base station apparatus according to the present embodiment.

FIG. **3** is a block diagram illustrating a composition example of a terminal apparatus according to the present embodiment.

DESCRIPTION OF EMBODIMENTS

A communication system in the present embodiment includes a base station apparatus (a transmission apparatus, a cell, a transmission point, a transmit antenna group, a transmit antenna port group, a component carrier, or an eNodeB) and a terminal apparatus (a terminal, a mobile terminal, a reception point, a reception terminal, a reception apparatus, a receive antenna group, a receive antenna port group, or UE).

In the present embodiment, "X/Y" includes the meaning of "X or Y". In the present embodiment, "X/Y" includes the meaning of "X and Y". In the present embodiment, "X/Y" includes the meaning of "X and/or Y".

FIG. **1** is a diagram illustrating an example of the communication system according to the present embodiment. As illustrated in FIG. **1**, the communication system in the present embodiment includes base station apparatuses **1**A and **1**B and terminal apparatuses **2**A, **2**B, and **2**C. A coverage **1-1** is an area (communication area) in which the base station apparatus **1**A can be connected with a terminal apparatus. A coverage **1-2** is an area (communication area) in which the base station apparatus **1**B can be connected with a terminal apparatus. Hereinafter, the terminal apparatuses **2**A and **2**B may be described as a terminal apparatus **2**.

In FIG. **1**, in the case of the base station apparatus **1**A spatially multiplexing the terminal apparatus **2**A and the terminal apparatus **2**B or in the case of the terminal apparatus **2** receiving inter-cell interference from the base station apparatus **1**B, receive signals in the terminal apparatus **2** include a desired signal destined for the terminal apparatus **2** (referred to as a first terminal apparatus) and a signal destined for an interfering terminal apparatus (referred to as a second terminal apparatus). Specifically, receive signals in the terminal apparatus **2**A include a desired signal destined for the terminal apparatus **2**A and transmitted from the base station apparatus **1**A and interference signals of a signal destined for the terminal apparatus **2**B and a signal destined for the terminal apparatus **2**C and transmitted from the base station apparatus **1**B. Receive signals in the terminal apparatus **2**B include a desired signal destined for the terminal apparatus **2**B and transmitted from the base station apparatus **1**A and interference signals of a signal destined for the terminal apparatus **2**A and a signal destined for the terminal apparatus **2**C and transmitted from the base station apparatus **1**B.

In the present embodiment, a base station apparatus spatially multiplexes a plurality of terminal apparatuses. Thus, the present invention is preferably for the case of the terminal apparatus receiving inter-user interference or the case of the terminal apparatus receiving inter-cell interference from another base station apparatus and is not limited to the communication system of FIG. **1**. Inter-user interference and inter-cell interference are not required to be received at the same time. The present invention includes any of the case of receiving only inter-user interference and the case of receiving only inter-cell interference.

The following uplink physical channels are used in uplink radio communication from the terminal apparatus **2** to the base station apparatus **1**A in FIG. **1**. The uplink physical channels are used in order to transmit information output from a higher layer.

Physical uplink control channel (PUCCH)
Physical uplink shared channel (PUSCH)
Physical random access channel (PRACH)

PUCCH is used in order to transmit uplink control information (UCI). The uplink control information includes a positive acknowledgement (ACK) or a negative acknowledgement (NACK) (ACK/NACK) for downlink data (downlink transport block or downlink shared channel (DL-SCH)). ACK/NACK for downlink data may be referred to as HARQ-ACK or HARQ feedback.

The uplink control information includes channel state information (CSI) for a downlink. In addition, the uplink control information includes a scheduling request (SR) that is used in order to request the resource of an uplink shared channel (UL-SCH). The channel state information corresponds to a rank indicator RI that specifies an appropriate number of spatial multiplexing, a precoding matrix indicator PMI that specifies an appropriate precoder, a channel quality indicator CQI that specifies an appropriate transmission rate, and the like.

The channel quality indicator CQI (hereinafter, a CQI value) can be an appropriate modulation scheme (for example, QPSK, 16QAM, 64QAM, or 256QAM) in a prescribed band (described in detail later) or a code rate. The CQI value can be an index (CQI index) that is determined by the change scheme or the code rate. The CQI value can be determined in advance in the system.

The rank indicator and the precoding quality indicator can be determined in advance in the system. The rank indicator or the precoding matrix indicator can be an index that is

determined by the number of spatial multiplexing or precoding matrix information. The rank indicator, the precoding matrix indicator, and the value of the channel quality indicator CQI are collectively referred to as a CSI value.

PUSCH is used in order to transmit uplink data (uplink transport block or UL-SCH). PUSCH may be used in order to transmit ACK/NACK and/or the channel state information along with the uplink data. In addition, PUSCH may be used in order to transmit only the uplink control information.

PUSCH is used in order to transmit an RRC message. The RRC message is information/signal that is processed in a radio resource control (RRC) layer. In addition, PUSCH is used in order to transmit an MAC control element (CE). MAC CE is information/signal that is processed (transmitted) in a medium access control (MAC) layer.

For example, power headroom may be included in MAC CE and reported via PUSCH. That is, a field of MAC CE may be used in order to indicate the level of power headroom.

PRACH is used in order to transmit a random access preamble.

In uplink radio communication, an uplink reference signal (UL RS) is used as an uplink physical signal. The uplink physical signal is not used for transmitting information output from a higher layer and is used by a physical layer. The uplink reference signal includes a demodulation reference signal (DMRS) and a sounding reference signal (SRS).

DMRS is associated with transmission in PUSCH or PUCCH. For example, the base station apparatus **1**A uses DMRS in order to perform propagation channel correction of PUSCH or PUCCH. SRS is not associated with transmission in PUSCH or PUCCH. For example, the base station apparatus **1**A uses SRS in order to measure the uplink channel state.

The following downlink physical channels are used in downlink radio communication from the base station apparatus **1**A to the terminal apparatus **2** in FIG. **1**. The downlink physical channels are used in order to transmit information output from a higher layer.

- Physical broadcast channel (PBCH)
- Physical control format indicator channel (PCFICH)
- Physical hybrid automatic repeat request indicator channel (PHICH; HARQ indicator channel)
- Physical downlink control channel (PDCCH)
- Enhanced physical downlink control channel (EPDCCH)
- Physical downlink shared channel (PDSCH)

PBCH is used in order to broadcast master information block (MIB; broadcast channel (BCH)) that is used in common in the terminal apparatus **2**. PCFICH is used in order to transmit information that indicates a region (for example, the number of OFDM symbols) used in transmission in PDCCH.

PHICH is used in order to transmit ACK/NACK for uplink data (transport block or code word) received by the base station apparatus **1**A. That is, PHICH is used in order to transmit an HARQ indicator (HARQ feedback) that indicates ACK/NACK for the uplink data. ACK/NACK is referred to as HARQ-ACK as well. The terminal apparatus **2** notifies a higher layer of the received ACK/NACK. ACK/NACK includes ACK that indicates correct reception, NACK that indicates incorrect reception, and DTX that indicates that there is no corresponding data. In the case of PHICH not existing for uplink data, the terminal apparatus **2** notifies a higher layer of ACK.

PDCCH and EPDCCH are used in order to transmit downlink control information (DCI). A plurality of DCI formats is defined for transmission of the downlink control information. That is, a field for the downlink control information is defined in a DCI format and is mapped to an information bit.

As a DCI format for the downlink, for example, a DCI format 1A that is used in scheduling of one PDSCH (transmission of one downlink transport block) in one cell is defined.

The DCI format for the downlink, for example, includes the downlink control information such as information related to PDSCH resource assignment, information related to a modulation and coding scheme (MCS) for PDSCH, and a TPC command for PUCCH. The DCI format for the downlink is referred to as downlink grant (or downlink assignment) as well.

As a DCI format for an uplink, for example, a DCI format 0 that is used in scheduling of one PUSCH (transmission of one uplink transport block) in one cell is defined.

The DCI format for the uplink, for example, includes the uplink control information such as information related to PUSCH resource assignment, information related to MCS for PUSCH, and a TPC command for PUSCH. The DCI format for the uplink is referred to as uplink grant (or uplink assignment) as well.

The DCI format for the uplink can be used in order to request the channel state information (CSI; referred to as reception quality information as well) of the downlink (CSI request). The channel state information corresponds to the rank indicator (RI) that specifies an appropriate number of spatial multiplexing, the precoding matrix indicator (PMI) that specifies an appropriate precoder, the channel quality indicator (CQI) that specifies an appropriate transmission rate, and the like.

The DCI format for the uplink can be used for a configuration that indicates an uplink resource to which a channel state information report (CSI feedback report) fed back to the base station apparatus by the terminal apparatus is mapped. For example, the channel state information report can be used for a configuration indicating an uplink resource that periodically reports the channel state information (periodic CSI). The channel state information report can be used in order to configure a mode (CSI report mode) that periodically reports the channel state information.

For example, the channel state information report can be used for a configuration indicating an uplink resource that reports aperiodic channel state information (aperiodic CSI). The channel state information report can be used in order to configure a mode (CSI report mode) that aperiodically reports the channel state information. The base station apparatuses **1**A and **1**B can configure any of the periodic channel state information report and the aperiodic channel state information report. In addition, the base station apparatuses **1**A and **1**B can configure both of the periodic channel state information report and the aperiodic channel state information report.

The DCI format for the uplink can be used for a configuration that indicates the type of the channel state information report fed back to the base station apparatus by the terminal apparatus. The type of the channel state information report is wideband CSI (for example, wideband CQI), narrowband CSI (for example, subband CQI), or the like.

The DCI format for the uplink can be used in order to configure a mode that includes the periodic channel state information report or the aperiodic channel state information report and the type of the channel state information report. For example, there is a mode that reports the aperiodic channel state information report and wideband CSI, a mode that reports the aperiodic channel state information report

and narrowband CSI, a mode that reports the aperiodic channel state information report, wideband CSI, and narrowband CSI, a mode that reports the periodic channel state information report and wideband CSI, a mode that reports the periodic channel state information report and narrowband CSI, a mode that reports the periodic channel state information report, wideband CSI, and narrowband CSI, or the like.

The terminal apparatus **2**, in the case of the resource of PDSCH being scheduled by using downlink assignment, receives downlink data in scheduled PDSCH. The terminal apparatus **2**, in the case of the resource of PUSCH being scheduled by using uplink grant, transmits uplink data and/or the uplink control information in scheduled PUSCH.

PDSCH is used in order to transmit downlink data (downlink transport block or DL-SCH). In addition, PDSCH is used in order to transmit a system information block type **1** message. The system information block type **1** message is cell-specific information.

PDSCH is used in order to transmit a system information message. The system information message includes a system information block X other than a system information block type **1**. The system information message is cell-specific information.

PDSCH is used in order to transmit an RRC message. An RRC message transmitted from the base station apparatus **1**A may be common to the plurality of terminal apparatuses **2** in a cell. The RRC message transmitted from the base station apparatus **1**A may be a message dedicated to a certain terminal apparatus **2** (referred to as dedicated signaling as well). That is, information that is specific to a user apparatus is transmitted by using a message dedicated to a certain terminal apparatus **2**. In addition, PDSCH is used in order to transmit MAC CE.

An RRC message and/or MAC CE is referred to as higher layer signaling as well.

PDSCH can be used in order to request downlink channel state information. In addition, PDSCH can be used in order to transmit an uplink resource to which the channel state information report (CSI feedback report) fed back to the base station apparatus by the terminal apparatus is mapped. For example, the channel state information report can be used for a configuration indicating an uplink resource that periodically reports the channel state information (periodic CSI). The channel state information report can be used in order to configure a mode (CSI report mode) that periodically reports the channel state information.

The type of the downlink channel state information report is wideband CSI (for example, wideband CSI) or narrowband CSI (for example, subband CSI). Wideband CSI calculates one piece of channel state information for the system band of a cell. Narrowband CSI divides the system band in prescribed units and calculates one piece of channel state information for the division.

In downlink radio communication, a synchronization signal (SS) and a downlink reference signal (DL RS) are used as a downlink physical signal. The downlink physical signal is not used for transmitting information output from a higher layer and is used by the physical layer.

The synchronization signal is used in order for the terminal apparatus **2** to synchronize a downlink frequency domain with a time domain. The downlink reference signal is used in order for the terminal apparatus **2** to perform propagation channel correction of the downlink physical channel. For example, the downlink reference signal is used in order for the terminal apparatus **2** to calculate the downlink channel state information.

The downlink reference signal includes a cell-specific reference signal (CRS), a UE-specific reference signal (URS) associated with PDSCH, a demodulation reference signal (DMRS) associated with EPDCCH, a non-zero power channel state information reference signal (NZP CSI-RS), and a zero power channel state information reference signal (ZP CSI-RS).

CRS is transmitted in the entire band of a subframe and is used in order to demodulate PBCH/PDCCH/PHICH/PCFICH/PDSCH. URS that is associated with PDSCH is transmitted in a subframe and a band used in transmission of PDSCH with which URS is associated, and is used in order to demodulate PDSCH with which URS is associated.

DMRS that is associated with EPDCCH is transmitted in a subframe and a band used in transmission of EPDCCH with which DMRS is associated. DMRS is used in order to demodulate EPDCCH with which DMRS is associated.

The resource of NZP CSI-RS is configured by the base station apparatus **1**A. For example, the terminal apparatus **2** measures a signal (measures a channel) by using NZP CSI-RS. The resource of ZP CSI-RS is configured by the base station apparatus **1**A. The base station apparatus **1**A transmits ZP CSI-RS as a zero output. For example, the terminal apparatus **2** measures interference in the resource to NZP CSI-RS corresponds.

The resource of ZP CSI-RS is configured by the base station apparatus **1**A. The base station apparatus **1**B transmits ZP CSI-RS as a zero output. That is, the base station apparatus **1**A does not transmit ZP CSI-RS. The base station apparatus **1**B does not transmit PDSCH and EPDCCH in the configured resource of ZP CSI-RS. The terminal apparatus **2**C can measure interference in, for example, the resource to which NZP CSI-RS corresponds in a certain cell.

Multimedia broadcast multicast service single frequency network (MBSFN) RS is transmitted in the entire band of a subframe used in transmission of PMCH. MBSFN RS is used in order to demodulate PMCH. PMCH is transmitted in an antenna port used in transmission of MBSFN RS.

The downlink physical channel and the downlink physical signal are collectively referred to as a downlink signal as well. The uplink physical channel and the uplink physical signal are collectively referred to as an uplink signal as well. The downlink physical channel and the uplink physical channel are collectively referred to as a physical channel as well. The downlink physical signal and the uplink physical signal are collectively referred to as a physical signal as well.

BCH, UL-SCH, and DL-SCH are transport channels. A channel that is used in the MAC layer is referred to as a transport channel. The unit of the transport channel used in the MAC layer is referred to as a transport block (TB) or a MAC protocol data unit (PDU) as well. The transport block is the unit of data that the MAC layer passes (delivers) to the physical layer. In the physical layer, the transport block is mapped to a code word, and a coding process or the like is performed for each code word.

The terminal apparatus can include a function of canceling or suppressing inter-user interference or inter-cell interference. Such a technology is under review as network assisted interference cancellation and suppression (NAICS) by 3rd Generation Partnership Project (3GPP). In NAICS, the base station apparatus transmits NAICS assistance information (called first assistance information as well) that the terminal apparatus uses in order to handle, cancel, or suppress an interference signal. The terminal apparatus receives the NAICS assistance information, detects a parameter for cancellation or suppression of an interference signal on the

basis of the NAICS assistance information, and cancels or suppresses an interference signal by using the parameter. The NAICS assistance information includes a part or the entirety of cell ID, the number of CRS antenna ports, an MBSFN subframe pattern, PB, virtual cell ID, a scrambling identity (nSCID), PA, a transmission mode, quasi co-location information (QCL information), a ZP/NZP CSI-RS configuration, a PDSCH starting position, a TDD UL/DL configuration, a precoding matrix indicator/rank indicator, a modulation scheme, and resource assignment information.

PA is the power ratio of PDSCH and CRS in an OFDM symbol where CRS is not arranged. PB represents the power ratio of PDSCH in an OFDM symbol where CRS is arranged and PDSCH in an OFDM symbol where CRS is not arranged. QCL information is information related to QCL for a prescribed antenna port, a prescribed signal, or a prescribed channel. For two antenna ports, in a case where the long-term characteristic of a channel in which a symbol on one antenna port is transported can be estimated from a channel in which a symbol on another antenna port is transported, these antenna ports are called QCL. The long-term characteristic includes a delay spread, a Doppler spread, a Doppler shift, an average gain and/or an average delay. That is, in the case of two antenna ports being QCL, the terminal apparatus can regard the long-term characteristics in these antenna ports as being the same.

Each parameter included in the NAICS assistance information may have one value (candidate) configured or may have a plurality of values (candidates) configured. In the case of configuring a plurality of values, the terminal apparatus analyzes the parameter as indicating a value that is likely to be configured by an interfering base station apparatus, and detects a parameter configured for an interference signal from the plurality of values. The NAICS assistance information may indicate information as to another base station apparatus or may indicate information as to the base station apparatus.

The NAICS assistance information is used by the terminal apparatus at the time of demodulating PDSCH for the terminal apparatus in order to handle, cancel, or suppress interference from PDSCH for another terminal apparatus. Thus, the NAICS assistance information is called PDSCH interference assistance information or PDSCH assistance information. The NAICS assistance information includes at least information related to mapping with respect to a resource element of PDSCH for another terminal apparatus. The NAICS assistance information may be used at the time of performing various measurements. The measurements include a radio resource management (RRM) measurement, a radio link monitoring (RLM) measurement, and a channel state information (CSI) measurement.

The terminal apparatus detects (specifies) PDSCH interference on the basis of the configured NAICS assistance information and mitigates the detected PDSCH interference. The NAICS assistance information may include quasi-static control information having a comparatively long update frequency and not include dynamic control information having a comparatively short update frequency. The quasi-static control information includes cell ID, the number of CRS antenna ports, an MBSFN subframe pattern, PB, virtual cell ID, a scrambling identity (nSCID), PA, a transmission mode, quasi co-location information (QCL information), a ZP/NZP CSI-RS configuration, a PDSCH starting position, a TDD UL/DL configuration, and the like. The dynamic control information includes a precoding matrix indicator/rank indicator, a modulation scheme, resource assignment information, and the like. As described previously, each parameter included in the NAICS assistance information may have a plurality of values (candidates) configured. Thus, the NAICS assistance information can be regarded as information for indicating a plurality of PDSCH interference candidates. The terminal apparatus can perform blind detection that tries detecting, in order, PDSCH interference candidates which can be recognized on the basis of the NAICS assistance information.

Accordingly, the terminal apparatus can mitigate interference from PDSCH for another terminal apparatus on the basis of the parameter detected from the NAICS assistance information and thus can accurately acquire a signal destined for the terminal apparatus. In addition, since the NAICS assistance information indicates a plurality of candidates, less influence can be exerted on scheduling of the base station apparatus. The terminal apparatus may be said to perform blind detection of a parameter that is not received as the assistance information. Cancellation or suppression of an interference signal can be performed by linear detection or non-linear detection. The linear detection allows detection considering a channel of a desired signal destined for the terminal apparatus and a channel of an interference signal destined for another terminal apparatus. Such linear detection is called enhanced linear minimum mean square error interference rejection combining (ELMMSE-IRC) as well. As the non-linear detection, an interference canceller or maximum likelihood detection can be used.

The base station apparatus can change the NAICS assistance information into a list as an NAICS assistance information list and transmit the NAICS assistance information list. The NAICS assistance information list can include at least one piece of NAICS assistance information. In addition, the NAICS assistance information list can be transmitted as neighbor cell NAICS information (called first interference information as well). The NAICS assistance information list may be called a PDSCH assistance information list as well. The neighbor cell NAICS information may be called neighbor cell PDSCH information as well.

The terminal apparatus, in the case of interference from CRS transmitted from another base station apparatus, can mitigate interference received from CRS of another base station apparatus by using CRS assistance information (called second support information as well) that is transmitted by a higher layer signal from the base station apparatus. The CRS assistance information is information as to another base station apparatus and includes cell ID, the number of CRS antenna ports, and an MBSFN subframe configuration list.

The CRS assistance information is transmitted after changing into a list by a CRS assistance information list. The CRS assistance information list includes at least one piece of CRS assistance information. The CRS assistance information list is transmitted as neighbor cell CRS information (called second interference information as well).

The CRS assistance information is used by the terminal apparatus at the time of demodulating PDSCH for the terminal apparatus in order to handle, cancel, or suppress interference from CRS of another cell (neighbor cell). The CRS assistance information may be used at the time of performing various measurements. The measurements include a radio resource management (RRM) measurement, a radio link monitoring (RLM) measurement, and a channel state information (CSI) measurement.

The NAICS assistance information can be used by the terminal apparatus not only for PDSCH interference but also in the case of handling CRS interference or interference of other channels.

FIG. **2** is a schematic block diagram illustrating composition of the base station apparatus **1**A in the present embodiment. As illustrated in FIG. **2**, the base station apparatus **1**A is constituted to include a higher layer processing unit **101**, a control unit **102**, a transmission unit **103**, a reception unit **104**, and a transmit and receive antenna **105**. The higher layer processing unit **101** is constituted to include a radio resource control unit **1011** and a scheduling unit **1012**. The transmission unit **103** is constituted to include a coding unit **1031**, a modulation unit **1032**, a downlink reference signal generation unit **1033**, a multiplexing unit **1034**, and a radio transmission unit **1035**. The reception unit **104** is constituted to include a radio reception unit **1041**, a demultiplexing portion **1042**, a demodulation unit **1043**, and a decoding unit **1044**.

The higher layer processing unit **101** performs processing in a medium access control (MAC) layer, a packet data convergence protocol (PDCP) layer, a radio link control (RLC) layer, and a radio resource control (RRC) layer. The higher layer processing unit **101** generates information required for controlling the transmission unit **103** and the reception unit **104** and outputs the information to the control unit **102**.

The higher layer processing unit **101** receives information related to the terminal apparatus, such as the function of the terminal apparatus (UE capability), from the terminal apparatus. In other words, the terminal apparatus transmits the function thereof to the base station apparatus by using a higher layer signal.

In the following description, information related to the terminal apparatus includes information that indicates whether or not the terminal apparatus supports a prescribed function, or information that indicates whether or not introduction and test for a prescribed function of the terminal apparatus are completed. In the following description, whether or not to support a prescribed function includes whether or not introduction and test for a prescribed function are completed.

For example, in the case of the terminal apparatus supporting a prescribed function, the terminal apparatus transmits information (parameter) that indicates whether or not to support the prescribed function. In the case of the terminal apparatus not supporting the prescribed function, the terminal apparatus does not transmit information (parameter) that indicates whether or not to support the prescribed function. That is, whether or not to support the prescribed function is notified by whether or not to transmit information (parameter) that indicates whether or not to support the prescribed function. Information (parameter) that indicates whether or not to support a prescribed function may be notified by using one bit of 1 or 0.

The function of the terminal apparatus can include a parameter that indicates whether or not NAICS is supported. In the case of NAICS having a plurality of functions, the terminal apparatus can transmit individual parameters indicating whether or not each function is supported to the base station apparatus. For example, in the case of two functions PDSCH interference handling and CRS interference handling being included as NAICS, the terminal apparatus can transmit, to the base station apparatus, a signal indicating whether or not PDSCH interference handling is supported and a signal indicating whether or not CRS interference handling is supported. Specifically, in the case of the terminal apparatus supporting CRS interference handling and PDSCH interference handling, the terminal apparatus transmits information (parameter) that indicates whether or not to support CRS interference handling, and information (parameter) that indicates whether or not to support PDSCH interference handling. In the case of the terminal apparatus supporting CRS interference handling and not supporting PDSCH interference handling, the terminal apparatus transmits information (parameter) that indicates whether or not to support CRS interference handling, and does not transmit information (parameter) that indicates whether or not to support PDSCH interference handling.

The terminal apparatus that supports PDSCH interference handling may mandatorily support CRS interference handling. That is, the terminal apparatus, in the case of transmitting information (parameter) that indicates whether or not to support PDSCH interference handling, also transmits information (parameter) that indicates whether or not to support CRS interference handling.

The terminal apparatus in a prescribed release thereof may mandatorily support CRS interference handling and optionally support PDSCH interference handling. The terminal apparatus in a prescribed release thereof may mandatorily support CRS interference handling and PDSCH interference handling.

In the case of the terminal apparatus supporting PDSCH interference handling, the terminal apparatus may be represented as having a function of handling both of PDSCH interference and CRS interference. That is, the base station apparatus, in the case of receiving, from the terminal apparatus, a report stating that PDSCH interference handling is supported, can determine the terminal apparatus to have a function of CRS interference handling regardless of whether or not CRS interference handling is supported. The terminal apparatus, in the case of supporting PDSCH interference handling, may report to the base station apparatus that CRS interference handling is mandatorily supported.

The function of CRS interference handling may include first CRS interference handling in which transmission is performed to the base station apparatus independently of NAICS, and second CRS interference handling that is CRS interference handling as a function of a part of the function of NAICS. The terminal apparatus can transmit, to the base station apparatus, both of whether or not the first CRS interference handling is supported and whether or not the second CRS interference handling is supported.

The higher layer processing unit **101** determines whether or not to configure the NAICS assistance information and whether or not to configure the CRS assistance information. The base station apparatus can determine whether or not to configure the NAICS/CRS assistance information from the function of the terminal apparatus.

The radio resource control unit **1011** generates, or acquires from a higher node, downlink data (transport block) arranged in downlink PDSCH, system information, an RRC message, MAC CE, and the like. The radio resource control unit **1011** outputs the downlink data to the transmission unit **103** and outputs other information to the control unit **102**. In addition, the radio resource control unit **1011** manages various types of configuration information as to the terminal apparatus **2**. These types of configuration information can include configuration information as to an interfering terminal apparatus. Alternatively, configuration information as to an interfering terminal apparatus can be acquired from configuration information as to the terminal apparatus. In addition, configuration information as to an interfering base station apparatus can be included.

The base station apparatus can transmit the NAICS assistance information and/or the CRS assistance information to the terminal apparatus that has a capability of canceling NAICS and/or CRS interference.

In the case of the terminal apparatus supporting carrier aggregation (CA), the base station apparatus can configure the NAICS assistance information and/or the CRS assistance information for a primary cell (pcell) and/or a secondary cell (scell). In the description of the present embodiment, the NAICS assistance information and/or the CRS assistance information is simply called assistance information as well.

In this case, the base station apparatus can configure different assistance information for each cell. For example, the base station apparatus can configure any of the CRS assistance information and the NAICS assistance information in the pcell and configure only the NAICS assistance information in the scell. For example, the base station apparatus can configure the CRS assistance information and the NAICS assistance information in the pcell and configure only the NAICS assistance information in the scell. That is, the CRS assistance information may not be able to be configured in the scell.

The base station apparatus can individually configure the CRS assistance information (NAICS assistance information) for the pcell and the CRS assistance information (NAICS assistance information) for the scell. The CRS assistance information (NAICS assistance information) for the pcell and the CRS assistance information (NAICS assistance information) for the scell can include different information (parameter or configuration). For example, the CRS assistance information (NAICS assistance information) for the pcell can be assistance information for the first CRS interference handling, and the CRS assistance information (NAICS assistance information) for the scell can be assistance information for the second CRS interference handling. The base station apparatus can use the CRS assistance information (NAICS assistance information) for the pcell and the CRS assistance information (NAICS assistance information) for the scell as assistance information for the second CRS interference handling (assistance information for second PDSCH interference handling). In this case, the base station apparatus can configure (prescribe or define) optional information (parameter or configuration) to be different in the CRS assistance information (NAICS assistance information) for the pcell and the CRS assistance information (NAICS assistance information) for the scell. The optional information represents information that is not necessarily required to be configured, or information that can be determined to be configured or not by the base station apparatus.

The base station apparatus can limit the number of cells in which the CRS assistance information and/or the NAICS assistance information is configured. Limiting the number of cells in which the CRS assistance information and/or the NAICS assistance information is configured limits interference parameters required by the terminal apparatus and thus can reduce the amount of calculation of the terminal apparatus. The base station apparatus can limit configuration of the CRS assistance information and/or the NAICS assistance information to one cell. For example, the CRS assistance information and/or the NAICS assistance information is configured in only one cell of the pcell and the scell. The base station apparatus can limit configuration of the CRS assistance information and/or the NAICS assistance information to each cell. For example, the base station apparatus can perform the configuration in maximum two cells of the pcell and one scell.

The base station apparatus mandatorily includes physical cell ID, the number of CRS antenna ports, and an MBSFN subframe structure as mandatory information (parameter) in the NAICS assistance information and can use other information as optional information. Specifically, the optional information includes a part or the entirety of PB, virtual cell ID, a scrambling identity (nSCID), PA, a transmission mode, quasi co-location information (QCL information), a ZP/NZP CSI-RS configuration, a PDSCH starting position, a TDD UL/DL configuration, a precoding matrix indicator/rank indicator, a modulation scheme, and resource assignment information.

In the case of including only the physical cell ID, the number of CRS antenna ports, and the MBSFN subframe structure in the NAICS assistance information, or in the case of the optional information not being completely configured in the NAICS assistance information, the terminal apparatus does not assume PDSCH interference. That is, the terminal apparatus assumes only CRS interference and handles, cancels, or suppresses only CRS interference.

The base station apparatus, in the case of the function of the terminal apparatus reported from the terminal apparatus being CRS interference handling, transmits only the physical cell ID, the number of CRS antenna ports, and the MBSFN subframe structure as the NAICS assistance information or transmits the NAICS assistance information without completely configuring the optional information.

The scheduling unit **1012** determines a frequency and a subframe to which a physical channel (PDSCH and PUSCH) is assigned, a code rate and a modulation scheme (or MCS) for a physical channel (PDSCH and PUSCH), transmit power, and the like. The scheduling unit **1012** outputs determined information to the control unit **102**.

The scheduling unit **1012** generates information used in scheduling of a physical channel (PDSCH and PUSCH) on the basis of a scheduling result. The scheduling unit **1012** outputs generated information to the control unit **102**. In the present embodiment, the scheduling unit **1012**, for example, schedules the terminal apparatus **2**A and the terminal apparatus **2**B in the same resource. While the same resource is used for simplification purposes in the present embodiment, the terminal apparatus **2**A and the terminal apparatus **2**B may be scheduled in different resources. Scheduling can also be performed in cooperation with the base station apparatus **1**B.

The control unit **102**, on the basis of information input from the higher layer processing unit **101**, generates a control signal that controls the transmission unit **103** and the reception unit **104**. The control unit **102** generates the downlink control information on the basis of information input from the higher layer processing unit **101** and outputs the downlink control information to the transmission unit **103**.

The transmission unit **103**, in accordance with the control signal input from the control unit **102**, generates a downlink reference signal, codes and modulates the HARQ indicator, the downlink control information, and the downlink data input from the higher layer processing unit **101**, multiplexes PHICH, PDCCH, EPDCCH, PDSCH, and the downlink reference signal, and transmits a signal to the terminal apparatus **2** through the transmit and receive antenna **105**.

The coding unit **1031** codes the HARQ indicator, the downlink control information, and the downlink data input from the higher layer processing unit **101** by using a predetermined coding scheme such as block coding, convolutional coding, and turbo coding or by using a coding scheme determined by the radio resource control unit **1011**. The modulation unit **1032** modulates a coding bit input from the coding unit **1031** by using a predetermined modulation scheme such as binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16 quadrature amplitude

modulation (QAM), 64QAM, and 256QAM or by using a modulation scheme determined by the radio resource control unit **1011**.

The downlink reference signal generation unit **1033** generates a sequence as the downlink reference signal, the sequence being known by the terminal apparatus **2** and being obtained by using a rule predetermined on the basis of a physical cell identifier (PCI or cell ID) for identification of the base station apparatus **1**A.

The multiplexing unit **1034** multiplexes a modulation symbol of each modulated channel and the generated downlink reference signal and the downlink control information. That is, the multiplexing unit **1034** arranges the modulation symbol of each modulated channel and the generated downlink reference signal and the downlink control information in a resource element.

The radio transmission unit **1035** performs an inverse fast Fourier transform (IFFT) of the multiplexed modulation symbol and the like to generate an OFDM symbol, adds a cyclic prefix (CP) to the OFDM symbol to generate a baseband digital signal, converts the baseband digital signal into an analog signal, removes an extraneous frequency component by filtering, converts the frequency of the analog signal up to a carrier frequency, amplifies the power of the analog signal, and outputs the analog signal to the transmit and receive antenna **105** to transmit the analog signal.

The reception unit **104**, in accordance with the control signal input from the control unit **102**, demultiplexes, demodulates, and decodes a receive signal received from the terminal apparatus **2** through the transmit and receive antenna **105** and outputs decoded information to the higher layer processing unit **101**.

The radio reception unit **1041** converts an uplink signal received through the transmit and receive antenna **105** into a baseband signal by downconversion, removes an unnecessary frequency component, controls an amplification level to appropriately maintain a signal level, performs quadrature demodulation on the basis of an in-phase component and a quadrature component of the received signal, and converts the quadrature demodulated analog signal into a digital signal.

The radio reception unit **1041** removes a component corresponding to CP from the converted digital signal. The radio reception unit **1041** performs a fast Fourier transform (FFT) of the signal from which CP is removed, and extracts and outputs a frequency domain signal to the demultiplexing portion **1042**.

The demultiplexing portion **1042** demultiplexes the signal input from the radio reception unit **1041** into signals such as PUCCH, PUSCH, and an uplink reference signal. This demultiplexing is performed on the basis of radio resource assignment information included in uplink grant that the base station apparatus **1**A determines in advance by using the radio resource control unit **1011** and notifies to each terminal apparatus **2**.

In addition, the demultiplexing portion **1042** compensates the propagation channels of PUCCH and PUSCH. In addition, the demultiplexing portion **1042** demultiplexes the uplink reference signal.

The demodulation unit **1043** performs an inverse discrete Fourier transform (IDFT) of PUSCH, acquires the modulation symbol, and demodulates the receive signal for each modulation symbol of PUCCH and PUSCH by using a predetermined modulation scheme such as BPSK, QPSK, 16QAM, 64QAM, and 256QAM or by using a modulation scheme that the base station apparatus **1**A notifies in advance to each terminal apparatus **2** by using the uplink grant.

The decoding unit **1044** decodes a demodulated coding bit of PUCCH and PUSCH at a predetermined code rate of a predetermined coding scheme or at a predetermined code rate that the base station apparatus **1**A notifies in advance to the terminal apparatus **2** by using the uplink grant, and outputs the decoded uplink data and the uplink control information to the higher layer processing unit **101**. In the case of retransmitting PUSCH, the decoding unit **1044** performs decoding by using the demodulated coding bit and a coding bit retained in an HARQ buffer input from the higher layer processing unit **101**.

FIG. **3** is a schematic block diagram illustrating composition of the terminal apparatus **2** in the present embodiment. As illustrated in FIG. **3**, the terminal apparatus **2** is constituted to include a higher layer processing unit **201**, a control unit **202**, a transmission unit **203**, a reception unit **204**, a channel state information generating unit **205**, and a transmit and receive antenna **206**. The higher layer processing unit **201** is constituted to include a radio resource control unit **2011** and a scheduling information analysis unit **2012**. The transmission unit **203** is constituted to include a coding unit **2031**, a modulation unit **2032**, an uplink reference signal generation unit **2033**, a multiplexing unit **2034**, and a radio transmission unit **2035**. The reception unit **204** is constituted to include a radio reception unit **2041**, a demultiplexing portion **2042**, and a signal detection unit **2043**.

The higher layer processing unit **201** outputs uplink data (transport block) generated by a user operation or the like to the transmission unit **203**. In addition, the higher layer processing unit **201** performs processing in a medium access control (MAC) layer, a packet data convergence protocol (PDCP) layer, a radio link control (RLC) layer, and a radio resource control (RRC) layer.

The higher layer processing unit **201** outputs, to the transmission unit **203**, information that indicates the function of the terminal apparatus supported by the terminal apparatus.

The radio resource control unit **2011** manages various types of configuration information as to the terminal apparatus. In addition, the radio resource control unit **2011** generates information that is arranged in each uplink channel, and outputs the information to the transmission unit **203**.

The radio resource control unit **2011** acquires configuration information related to CSI feedback transmitted from the base station apparatus and outputs the configuration information to the control unit **202**.

The scheduling information analysis unit **2012** analyzes the downlink control information received through the reception unit **204** and determines scheduling information. In addition, the scheduling information analysis unit **2012**, on the basis of the scheduling information, generates control information for controlling the reception unit **204** and the transmission unit **203** and outputs the control information to the control unit **202**.

The control unit **202**, on the basis of information input from the higher layer processing unit **201**, generates a control signal that controls the reception unit **204**, the channel state information generating unit **205**, and the transmission unit **203**. The control unit **202** outputs the generated control signal to the reception unit **204**, the channel state information generating unit **205**, and the transmission unit **203** to control the reception unit **204** and the transmission unit **203**.

The control unit **202** controls the transmission unit **203** to transmit CSI generated by the channel state information generating unit **205** to the base station apparatus.

The reception unit **204**, in accordance with the control signal input from the control unit **202**, demultiplexes, demodulates, and decodes a receive signal received from the base station apparatus **1**A through the transmit and receive antenna **206** and outputs decoded information to the higher layer processing unit **201**. The reception unit **204** receives a reference signal corresponding to the base station apparatus **1**A (called a first reference signal as well) included in the receive signal and a reference signal based on interference information configured from the base station apparatus **1**A (called a second reference signal as well) and outputs the reference signals to the channel state information generating unit **205**.

The radio reception unit **2041** converts a downlink signal received through the transmit and receive antenna **206** into a baseband signal by downconversion, removes an unnecessary frequency component, controls an amplification level to appropriately maintain a signal level, performs quadrature demodulation on the basis of an in-phase component and a quadrature component of the received signal, and converts the quadrature demodulated analog signal into a digital signal.

In addition, the radio reception unit **2041** removes a part corresponding to CP from the converted digital signal, performs a fast Fourier transform of the signal from which CP is removed, and extracts a frequency domain signal.

The demultiplexing portion **2042** demultiplexes the extracted signal into PHICH, PDCCH, EPDCCH, PDSCH, and a downlink reference signal. In addition, the demultiplexing portion **2042**, on the basis of a channel estimation value of a desired signal acquired from channel measurement, compensates channels of PHICH, PDCCH, and EPDCCH and detects and outputs the downlink control information to the control unit **202**. The control unit **202** outputs PDSCH and the channel estimation value of the desired signal to the signal detection unit **2043**.

The signal detection unit **2043** detects a signal by using PDSCH and the channel estimation value and outputs the signal to the higher layer processing unit **201**. In the case of NAICS being configured in a higher layer, a signal is detected after canceling or suppressing an interference signal. To cancel or suppress an interference signal, for example, linear detection that considers a channel estimation value of the interference signal, or interference cancellation or maximum likelihood detection that considers a channel estimation value of the interference signal or a modulation scheme is performed.

The signal detection unit **2043**, in the case of the NAICS assistance information being configured in a higher layer, detects a parameter required for estimation of an interference channel and/or demodulation of an interference signal. For a parameter having a plurality of values configured in the NAICS assistance information, blind detection of a value configured in an interference signal is performed with the plurality of values as candidates. For a parameter that is not configured in the NAICS assistance information, blind detection of a value configured in an interference signal may be performed with a value that is likely to be configured in the system as a candidate. The signal detection unit **2043** cancels or suppresses PDSCH/CRS interference by using the detected parameter.

The signal detection unit **2043**, in the case of only the physical cell ID, the number of CRS antenna ports, and the MBSFN subframe structure being configured in the NAICS assistance information, cancels or suppresses an interference signal without assuming PDSCH interference. Alternatively, the terminal apparatus handles, cancels, or suppresses only CRS interference.

The transmission unit **203**, in accordance with the control signal input from the control unit **202**, generates an uplink reference signal, codes and modulates the uplink data (transport block) input from the higher layer processing unit **201**, and multiplexes and transmits PUCCH, PUSCH, and the generated uplink reference signal to the base station apparatus **1**A through the transmit and receive antenna **206**.

The coding unit **2031** codes the uplink control information input from the higher layer processing unit **201** by using convolutional coding, block coding, or the like. In addition, the coding unit **2031** performs turbo coding that is based on information used in scheduling of PUSCH.

The modulation unit **2032** modulates a coding bit input from the coding unit **2031** by using a modulation scheme such as BPSK, QPSK, 16QAM, and 64QAM notified by using the downlink control information or by using a modulation scheme that is predetermined for each channel.

The uplink reference signal generation unit **2033** generates a sequence that is obtained by a predetermined rule (formula), on the basis of a physical cell identifier (referred to as a physical cell identity, PCI, cell ID, or the like) for identification of the base station apparatus **1**A, a bandwidth in which the uplink reference signal is arranged, a cyclic shift notified by using the uplink grant, the value of a parameter for generation of a DMRS sequence, and the like.

The multiplexing unit **2034**, in accordance with the control signal input from the control unit **202**, performs a discrete Fourier transform (DFT) after arranging modulation symbols of PUSCH in parallel. In addition, the multiplexing unit **2034** multiplexes signals of PUCCH and PUSCH and the generated uplink reference signal for each transmit antenna port. That is, the multiplexing unit **2034** arranges signals of PUCCH and PUSCH and the generated uplink reference signal in a resource element for each transmit antenna port.

The radio transmission unit **2035** performs an inverse fast Fourier transform (IFFT) of the multiplexed signal, performs SC-FDMA modulation, generates an SC-FDMA symbol, adds CP to the generated SC-FDMA symbol, generates a baseband digital signal, converts the baseband digital signal into an analog signal, removes an extraneous frequency component, converts the frequency of the analog signal to a carrier frequency by upconversion, amplifies the power of the analog signal, and outputs the analog signal to the transmit and receive antenna **206** to transmit the analog signal.

A base station apparatus of the present invention is a base station apparatus that communicates with a terminal apparatus and includes a higher layer in which first support information used in the terminal apparatus in order to mitigate interference from at least a downlink shared channel is configured in the terminal apparatus. The first support information mandatorily includes a physical cell identifier, the number of cell-specific reference signal antenna ports, and an MBSFN subframe structure, and another information is arbitrarily configured.

In the base station apparatus of the present invention, information related to the function of the terminal apparatus is received from the terminal apparatus, and in the case of cell-specific interference handling being supported and downlink shared channel interference handling not being supported as the function of the terminal apparatus, only the physical cell identifier, the number of cell-specific reference

signal antenna ports, and the MBSFN subframe structure are transmitted as the first support information.

A terminal apparatus of the present invention is a terminal apparatus that communicates with a base station apparatus and is a terminal apparatus in which first support information used in the terminal apparatus in order to mitigate interference from at least a downlink shared channel is configured from the base station apparatus. The terminal apparatus assumes interference by a cell-specific reference signal without assuming interference from the downlink shared channel in the case of only a physical cell identifier, the number of cell-specific reference signal antenna ports, and an MBSFN subframe structure being configured as the first support information.

A communication method of the present invention is a communication method for a base station apparatus that communicates with a terminal apparatus, and includes a step of configuring, in the terminal apparatus, first support information used in the terminal apparatus in order to mitigate interference from at least a downlink shared channel. The first support information mandatorily includes a physical cell identifier, the number of cell-specific reference signal antenna ports, and an MBSFN subframe structure, and another information is arbitrarily configured.

A communication method of the present invention is a communication method for a terminal apparatus that communicates with a base station apparatus, and includes a reception step of receiving, from the base station apparatus, first support information used in the terminal apparatus in order to mitigate interference from at least a downlink shared channel, and a step of assuming interference by a cell-specific reference signal without assuming interference from the downlink shared channel in the case of only a physical cell identifier, the number of cell-specific reference signal antenna ports, and an MBSFN subframe structure being configured as the first support information.

A program that operates in the base station apparatus and the terminal apparatus according to the present invention is a program (a program that causes a computer to function) that controls a CPU and the like in order to realize the function of the above embodiment according to the present invention. Information that is handled by these apparatuses is temporarily accumulated in a RAM when being processed and then is stored in various ROMs or HDDs, and the CPU reads, modifies, or writes the information if necessary. A recording medium storing the program may be any of a semiconductor medium (for example, a ROM or a non-volatile memory card), an optical recording medium (for example, a DVD, an MO, an MD, a CD, or a BD), a magnetic recording medium (for example, a magnetic tape or a flexible disk), and the like. The function of the above embodiment is not realized only by execution of the loaded program. The function of the present invention may be realized by processing of the program along with an operating system, another application program, or the like on the basis of instructions of the program.

In the case of distributing the program in the market, the program can be distributed by being stored in a portable recording medium or can be transferred to a server computer that is connected through a network such as the Internet. In this case, the present invention includes a storage apparatus of the server computer as well. A part or the entirety of the terminal apparatus and the base station apparatus in the above embodiment may be typically realized as LSI that is an integrated circuit. Each functional block of the reception apparatus may be configured as an individual chip, or a part or the entire functional blocks may be integrated into a chip.

In the case of configuring each functional block as integrated circuits, an integrated circuit control unit that controls the integrated circuits is added.

A technique for the circuit integration is not limited to LSI and may be realized by a dedicated circuit or a general-purpose processor. In the case of emergence of a circuit integration technology that replaces LSI, due to advancement of semiconductor technology, an integrated circuit made by the technology can be used.

The present invention is not limited to the above embodiment. Application of the terminal apparatus of the present invention is not limited to a mobile station apparatus. Apparently, the terminal apparatus can be applied to a stationary type or non-movable type electronic equipment installed indoors or outdoors, such as an AV equipment, a kitchen equipment, a cleaning or washing machine, an air conditioner, an office equipment, a vending machine, and other daily life equipments.

While the embodiment of the invention is heretofore described in detail with reference to the drawings, specific composition of the invention is not limited to the embodiment. Designs and the like that are made to the extent not departing from the gist of the invention are also included in the claims.

INDUSTRIAL APPLICABILITY

The present invention is preferably used for a base station apparatus, a terminal apparatus, and a method.

The present international application claims the benefit of priority based on Japanese Patent Application No. 2014-160973 filed on Aug. 7, 2014. The entire contents of Japanese Patent Application No. 2014-160973 are incorporated in the present international application.

REFERENCE SIGNS LIST

1A, **1**B BASE STATION APPARATUS
2A, **2**B, **2**C TERMINAL APPARATUS
101 HIGHER LAYER PROCESSING UNIT
102 CONTROL UNIT
103 TRANSMISSION UNIT
104 RECEPTION UNIT
105 TRANSMIT AND RECEIVE ANTENNA
1011 RADIO RESOURCE CONTROL UNIT
1012 SCHEDULING UNIT
1031 CODING UNIT
1032 MODULATION UNIT
1033 DOWNLINK REFERENCE SIGNAL GENERATION UNIT
1034 MULTIPLEXING UNIT
1035 RADIO TRANSMISSION UNIT
1041 RADIO RECEPTION UNIT
1042 DEMULTIPLEXING PORTION
1043 DEMODULATION UNIT
1044 DECODING UNIT
201 HIGHER LAYER PROCESSING UNIT
202 CONTROL UNIT
203 TRANSMISSION UNIT
204 RECEPTION UNIT
205 CHANNEL STATE INFORMATION GENERATING UNIT
206 TRANSMIT AND RECEIVE ANTENNA
2011 RADIO RESOURCE CONTROL UNIT
2012 SCHEDULING INFORMATION ANALYSIS UNIT
2031 CODING UNIT

2032 MODULATION UNIT
2033 UPLINK REFERENCE SIGNAL GENERATION UNIT
2034 MULTIPLEXING UNIT
2035 RADIO TRANSMISSION UNIT
2041 RADIO RECEPTION UNIT
2042 DEMULTIPLEXING PORTION
2043 SIGNAL DETECTION UNIT

The invention claimed is:

1. A base station apparatus comprising

a transmission circuit configured and/or programmed to:

transmit cell-specific reference signal (CRS) assistance information to a terminal apparatus, wherein

the CRS assistance information includes information related to a physical cell ID, information related to a number of antenna ports for a cell-specific reference signal CRS, and information related to a multimedia broadcast multicast service single frequency network (MBSFN) subframe;

the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe are used to mitigate CRS interference from neighboring cells, and are configured for a primary cell and a secondary cell by the base station apparatus;

the primary cell and the secondary cell are used for carrier aggregation;

the CRS assistance information further includes optional information for the primary cell or the secondary cell, the optional information configured for the secondary cell in the carrier aggregation being different from the optional information configured for the primary cell in the carrier aggregation, the optional information including information that is not required to configure a cell and information that can be determined from the information already present in the base station apparatus; and

the optional information configured for the secondary cell includes at least one of the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe, the optional information configured for the secondary cell including none of the optional information configured for the primary cell in the CRS assistance information among the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe.

2. The base station apparatus according to claim 1,

wherein at least one of the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe, which are configured for the primary cell, is not configured for the secondary cell.

3. A method for a base station apparatus, the method comprising the step of:

transmitting CRS assistance information to a terminal apparatus,

wherein

the CRS assistance information includes information related to a physical cell ID, information related to a number of antenna ports for the CRS, and information related to an MBSFN subframe;

the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe are used to mitigate CRS interference from neighboring cells, and are configured for a primary cell and a secondary cell by the base station apparatus;

the primary cell and the secondary cell are used for carrier aggregation;

the CRS assistance information further includes optional information for the primary cell or the secondary cell, the optional information configured for the secondary cell in the carrier aggregation being different from the optional information configured for the primary cell in the carrier aggregation, the optional information including information that is not required to configure a cell and information that can be determined from the information already present in the base station apparatus; and

the optional information configured for the secondary cell includes at least one of the information related to a physical cell ID, the information related to a number of antenna ports for the RS, and the information related to an MBSFN subframe, the optional information configured for the secondary cell including none of the optional information configured for the primary cell in the CRS assistance information among the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe.

4. A terminal apparatus comprising

a reception circuit configured and/or programmed to:

receive CRS assistance information from a base station apparatus,

wherein the CRS assistance information includes information related to a physical cell ID, information related to a number of antenna ports for the CRS, and information related to an MBSFN subframe;

the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, the information related to an MBSFN subframe, and an information related to a transmission mode are used to mitigate CRS interference from neighboring cells, and are configured for a primary cell and a secondary cell by the base station apparatus;

the primary cell and the secondary cell are used for carrier aggregation;

the CRS assistance information further includes optional information for the primary cell or the secondary cell, the optional information configured for the secondary cell in the carrier aggregation being different from the optional information configured for the primary cell in the carrier aggregation, the optional information including information that is not required to configure a cell and information that can be determined from the information already present in the base station apparatus; and

the optional information configured for the secondary cell includes at least one of the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe, the optional information configured for the secondary cell including none of the optional information configured for the primary cell in the CRS assistance information among the information related to physical cell ID, the information related to a

number of antenna ports for the CRS, and the information related to an MBSFN subframe.

5. The terminal apparatus according to claim **4**,

wherein at least one of the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe, which are configured for the primary cell, is not configured for the secondary cell.

6. A method for a terminal apparatus, the method comprising the step of:

receiving CRS assistance information from a base station apparatus,

wherein the CRS assistance information includes information related to a physical cell ID, information related to a number of antenna ports for the CRS, and information related to an MBSFN subframe;

the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, the information related to an MBSFN subframe, and an information related to a transmission mode are used to mitigate CRS interference from neighboring cells, and are configured for a primary cell and a secondary cell by the base station apparatus;

the primary cell and the secondary cell are used for carrier aggregation;

the CRS assistance information further includes optional information for the primary cell or the secondary cell, the optional information configured for the secondary cell in the carrier aggregation being different from the optional information configured for the primary cell in the carrier aggregation, the optional information including information that is not required to configure a cell and information that can be determined from the information already present in the base station apparatus; and

the optional information configured for the secondary cell includes at least one of the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe, the optional information configured for the secondary cell including none of the optional information configured for the primary cell in the CRS assistance information among the information related to a physical cell ID, the information related to a number of antenna ports for the CRS, and the information related to an MBSFN subframe.

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